UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF HISTORY AND PHILOSOPHY OF SCIENCE

FREE SCHOOL LANE
CAMBRIDGE CB2 3RH
TEL: CAMBRIDGE (0223) 334540

FROM HEAD OF DEPARTMENT

PROFESSOR M. L. G. REDHEAD

4 January 1988

Prof. Paul Teller
Philosophy Department
University of Illinois at Chicago Circle
Chicago Circle
Illinois
U.S.A.

Dear Paul

I enclose a very rough draft of the first 80 pages or so of the book together with the uncorrected disk. Feel free to put in further corrections and additional material and so on as you see fit.

I would estimate that the present material would constitute something a bit more than a quarter of the whole book. Perhaps it would be useful if I sketch out very briefly my ideas for the other sections. In what follows I will refer to as my PSA paper as A, my Oxford Conference paper as B and my paper in Studies as C.

Chapter 6 will continue with a fairly standard presentation of canonical field quantization for the Shrodinger field, the Klein-Gordon field and the Dirac field at roughly the level of Wentzel, i.e. using box normalization and Fourier series decomposition rather than Fourier integrals. The Klein-Gordon and Dirac equations will already have been discussed as one-particle equations in chapter 5 (still to be written) in which the connection with the unitary representations of the Poincare group will be made clear and also the question of one particle localization will be analysed. There will follow a very brief discussion on path integrals without any attention to mathematical rigour or the functional calculus, and in Section 6.4 on axiomatics, I want to try and set down what the axiomaticon constructive approach to field theory consists in rather than analysing the Wightman or Haag-Kastler axioms in detail. So this will be a short section and essentially non- technical. In Chapter 7 I will discuss the wave particle duality issue essentially for noninteracting fields and based on my A and B, paying particular attention to the distinction between the spatial argument of the relativistic wave equations and the positional arguments for the one-particle relativistic equations transformed in the manner of Foldy and Wouthuysen. Chapter 8 will continue with the free fields,discussing vacuum fluctuations of localised field strengths,the question of coherent states the uncertain relation between particle number and phase, etc, and also a brief presentation of the physics of the Casimir effect. Chapter 9 will be concerned with interacting fields. The presentation will consist of analysing the N particles on a string problem as a simple model of the phonon, and contrast drawn between this quasi-particle and the original particles on the string. As a second example I will consider the theory of weakly interacting bosonic particle assemblies, where a linearized version of the interaction problem can be subjected to a normal mode analysis, and the notion of a quasi- particle extracted even for the interacting situation. All this of course is nonrelativistic and will lead on to discussion of the Feynman diagrams presented in terms of the solution of the Shrodinger equation using Green's functions and propagators with some quantitative remarks about the electron-positron field in the style of Feynman's original

DIRECT LINE: CAMBRIDGE (0223) 334556

paper. The relation, if any, of virtual particles to the vacuum fluctuation phenomena discussed in chapter 8 will be analysed together with the elementary uncertainty relation arguments for the range of nuclear forces, and the production of real particles by confinement of a field to within its own Compton wavelength. Finally I will explain the connection between Feynman propagators and vacuum expectation values of time-ordered products so that a statement can be made of the Dyson-Wick re-ordering theorem, perhaps taking QED as an example. In chapter 10 I would propose an initial anaylsis of the renormalisation procedure, analysis of the nested and overlapping divergencies, etc., together with the identification of the primitive divergent diagrams. This will set the scene for the Chapter on renormalization. I wouldn't propose giving any proof that all divergencies can be elimated, but merely indicate the different approaches, including substractions, counter terms, regularisations, etc., and present your own discussion of running coupling constants, the way they are connected to the renomalization group and the question of Landau singularities, which you dealt with very well in your own paper. Chapter 11 is essentially on topics connected with gauge field theories. I think we must deal with these topics, but only to highlight their methodological and philosophical significance, not to go into any technical detail, the level being roughly that of Aitchison in his delightful introduction to gauge field theories. Chapter 12 would be based on my own A and B with discussions about active and passive interpretations of symmetry and the different senses of the term unification as in my review article in BJPS. Chaper 13 will follow almost directly the discussion of my C. I don't think we need be any more technical than in that reference and more or less reproduce that material as it stands. Chapter 14 is I think essential to include in a book of this sort, which would relate to the ultimate nature of space and time and the question of the origin of the universe as a vacuum fluctuation,and is concerned with topics which you might have many interesting things to contribute to yourself. The final chapter 15 will simply be a short summary.

It should be clear that the most technical chapters will be Chapter 5, Chapter 10, Chapter 11 and Chapter 14, but as far as possible I would suggest keeping the mathematical level roughly the same as in the part already written. We certainly don't want to end up just competing with standard texts on gauge field theory.

Let me know what you think of all this. On a quite different point we have now invited John Earman to give his lectures in Cambridge on Tuesday and Wednesday,24 and 25 May. I am delighted to say he has accepted.

Give my best regards to Chantel and the boys,and wishing you all a happy New Year. With best regards,

Yours sincerely

Michael

UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF HISTORY AND PHILOSOPHY OF SCIENCE

FREE SCHOOL LANE
CAMBRIDGE CB2 3RH
TEL: CAMBRIDGE (0223) 334540

FROM HEAD OF DEPARTMENT

PROFESSOR M. L. G. REDHEAD

4 January 1988

Prof. Paul Teller
Philosophy Department
University of Illinois at Chicago Circle
Chicago Circle
Illinois
U.S.A.

Dear Paul

I enclose a very rough draft of the first 80 pages or so of the book together with the uncorrected disk. Feel free to put in further corrections and additional material and so on as you see fit.

I would estimate that the present material would constitute something a bit more than a quarter of the whole book. Perhaps it would be useful if I sketch out very briefly my ideas for the other sections. In what follows I will refer to as my PSA paper as A, my Oxford Conference paper as B and my paper in Studies as C.

Chapter 6 will continue with a fairly standard presentation of canonical field quantization for the Shrodinger field, the Klein-Gordon field and the Dirac field at roughly the level of Wentzel, i.e. using box normalization and Fourier series decomposition rather than Fourier integrals. The Klein-Gordon and Dirac equations will already have been discussed as one-particle equations in chapter 5 (still to be written) in which the connection with the unitary representations of the Poincare group will be made clear and also the question of one particle localization will be analysed. There will follow a very brief discussion on path integrals without any attention to mathematical rigour or the functional calculus, and in Section 6.4 on axiomatics, I want to try and set down what the axiomaticon constructive approach to field theory consists in rather than analysing the Wightman or Haag-Kastler axioms in detail. So this will be a short section and essentially non- technical. In Chapter 7 I will discuss the wave particle duality issue essentially for noninteracting fields and based on my A and B, paying particular attention to the distinction between the spatial argument of the relativistic wave equations and the positional arguments for the one-particle relativistic equations transformed in the manner of Foldy and Wouthuysen. Chapter 8 will continue with the free fields,discussing vacuum fluctuations of localised field strengths,the question of coherent states the uncertain relation between particle number and phase, etc, and also a brief presentation of the physics of the Casimir effect. Chapter 9 will be concerned with interacting fields. The presentation will consist of analysing the N particles on a string problem as a simple model of the phonon, and contrast drawn between this quasi-particle and the original particles on the string. As a second example I will consider the theory of weakly interacting bosonic particle assemblies, where a linearized version of the interaction problem can be subjected to a normal mode analysis, and the notion of a quasi- particle extracted even for the interacting situation. All this of course is nonrelativistic and will lead on to discussion of the Feynman diagrams presented in terms of the solution of the Shrodinger equation using Green's functions and propagators with some quantitative remarks about the electron-positron field in the style of Feynman's original

DIRECT LINE: CAMBRIDGE (0223) 334556

paper. The relation, if any, of virtual particles to the vacuum fluctuation phenomena discussed in chapter 8 will be analysed together with the elementary uncertainty relation arguments for the range of nuclear forces, and the production of real particles by confinement of a field to within its own Compton wavelength. Finally I will explain the connection between Feynman propagators and vacuum expectation values of time-ordered products so that a statement can be made of the Dyson-Wick re-ordering theorem, perhaps taking QED as an example. In chapter 10 I would propose an initial anaylsis of the renormalisation procedure, analysis of the nested and overlapping divergencies, etc., together with the identification of the primitive divergent diagrams. This will set the scene for the Chapter on renormalization. I wouldn't propose giving any proof that all divergencies can be elimated, but merely indicate the different approaches, including substractions, counter terms, regularisations, etc., and present your own discussion of running coupling constants, the way they are connected to the renomalization group and the question of Landau singularities, which you dealt with very well in your own paper. Chapter 11 is essentially on topics connected with gauge field theories. I think we must deal with these topics, but only to highlight their methodological and philosophical significance, not to go into any technical detail, the level being roughly that of Aitchison in his delightful introduction to gauge field theories. Chapter 12 would be based on my own A and B with discussions about active and passive interpretations of symmetry and the different senses of the term unification as in my review article in BJPS. Chaper 13 will follow almost directly the discussion of my C. I don't think we need be any more technical than in that reference and more or less reproduce that material as it stands. Chapter 14 is I think essential to include in a book of this sort, which would relate to the ultimate nature of space and time and the question of the origin of the universe as a vacuum fluctuation,and is concerned with topics which you might have many interesting things to contribute to yourself. The final chapter 15 will simply be a short summary.

It should be clear that the most technical chapters will be Chapter 5, Chapter 10, Chapter 11 and Chapter 14, but as far as possible I would suggest keeping the mathematical level roughly the same as in the part already written. We certainly don't want to end up just competing with standard texts on gauge field theory.

Let me know what you think of all this. On a quite different point we have now invited John Earman to give his lectures in Cambridge on Tuesday and Wednesday,24 and 25 May. I am delighted to say he has accepted.

Give my best regards to Chantel and the boys,and wishing you all a happy New Year. With best regards,

Yours sincerely

Michael

UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF HISTORY AND PHILOSOPHY OF SCIENCE

FREE SCHOOL LANE
CAMBRIDGE CB2 3RH
TEL: CAMBRIDGE (0223) 334540

FROM HEAD OF DEPARTMENT

PROFESSOR M. L. G. REDHEAD

4 January 1988

Prof. Paul Teller
Philosophy Department
University of Illinois at Chicago Circle
Chicago Circle
Illinois
U.S.A.

Dear Paul

I enclose a very rough draft of the first 80 pages or so of the book together with the uncorrected disk. Feel free to put in further corrections and additional material and so on as you see fit.

I would estimate that the present material would constitute something a bit more than a quarter of the whole book. Perhaps it would be useful if I sketch out very briefly my ideas for the other sections. In what follows I will refer to as my PSA paper as A, my Oxford Conference paper as B and my paper in Studies as C.

Chapter 6 will continue with a fairly standard presentation of canonical field quantization for the Shrodinger field, the Klein-Gordon field and the Dirac field at roughly the level of Wentzel, i.e. using box normalization and Fourier series decomposition rather than Fourier integrals. The Klein-Gordon and Dirac equations will already have been discussed as one-particle equations in chapter 5 (still to be written) in which the connection with the unitary representations of the Poincare group will be made clear and also the question of one particle localization will be analysed. There will follow a very brief discussion on path integrals without any attention to mathematical rigour or the functional calculus, and in Section 6.4 on axiomatics, I want to try and set down what the axiomaticon constructive approach to field theory consists in rather than analysing the Wightman or Haag-Kastler axioms in detail. So this will be a short section and essentially non- technical. In Chapter 7 I will discuss the wave particle duality issue essentially for noninteracting fields and based on my A and B, paying particular attention to the distinction between the spatial argument of the relativistic wave equations and the positional arguments for the one-particle relativistic equations transformed in the manner of Foldy and Wouthuysen. Chapter 8 will continue with the free fields,discussing vacuum fluctuations of localised field strengths,the question of coherent states the uncertain relation between particle number and phase, etc, and also a brief presentation of the physics of the Casimir effect. Chapter 9 will be concerned with interacting fields. The presentation will consist of analysing the N particles on a string problem as a simple model of the phonon, and contrast drawn between this quasi-particle and the original particles on the string. As a second example I will consider the theory of weakly interacting bosonic particle assemblies, where a linearized version of the interaction problem can be subjected to a normal mode analysis, and the notion of a quasi- particle extracted even for the interacting situation. All this of course is nonrelativistic and will lead on to discussion of the Feynman diagrams presented in terms of the solution of the Shrodinger equation using Green's functions and propagators with some quantitative remarks about the electron-positron field in the style of Feynman's original

DIRECT LINE: CAMBRIDGE (0223) 334556

paper. The relation, if any, of virtual particles to the vacuum fluctuation phenomena discussed in chapter 8 will be analysed together with the elementary uncertainty relation arguments for the range of nuclear forces, and the production of real particles by confinement of a field to within its own Compton wavelength. Finally I will explain the connection between Feynman propagators and vacuum expectation values of time-ordered products so that a statement can be made of the Dyson-Wick re-ordering theorem, perhaps taking QED as an example. In chapter 10 I would propose an initial anaylsis of the renormalisation procedure, analysis of the nested and overlapping divergencies, etc., together with the identification of the primitive divergent diagrams. This will set the scene for the Chapter on renormalization. I wouldn't propose giving any proof that all divergencies can be elimated, but merely indicate the different approaches, including substractions, counter terms, regularisations, etc., and present your own discussion of running coupling constants, the way they are connected to the renomalization group and the question of Landau singularities, which you dealt with very well in your own paper. Chapter 11 is essentially on topics connected with gauge field theories. I think we must deal with these topics, but only to highlight their methodological and philosophical significance, not to go into any technical detail, the level being roughly that of Aitchison in his delightful introduction to gauge field theories. Chapter 12 would be based on my own A and B with discussions about active and passive interpretations of symmetry and the different senses of the term unification as in my review article in BJPS. Chaper 13 will follow almost directly the discussion of my C. I don't think we need be any more technical than in that reference and more or less reproduce that material as it stands. Chapter 14 is I think essential to include in a book of this sort, which would relate to the ultimate nature of space and time and the question of the origin of the universe as a vacuum fluctuation,and is concerned with topics which you might have many interesting things to contribute to yourself. The final chapter 15 will simply be a short summary.

It should be clear that the most technical chapters will be Chapter 5, Chapter 10, Chapter 11 and Chapter 14, but as far as possible I would suggest keeping the mathematical level roughly the same as in the part already written. We certainly don't want to end up just competing with standard texts on gauge field theory.

Let me know what you think of all this. On a quite different point we have now invited John Earman to give his lectures in Cambridge on Tuesday and Wednesday,24 and 25 May. I am delighted to say he has accepted.

Give my best regards to Chantel and the boys,and wishing you all a happy New Year. With best regards,

Yours sincerely

Michael

UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF HISTORY AND PHILOSOPHY OF SCIENCE

FREE SCHOOL LANE
CAMBRIDGE CB2 3RH
TEL: CAMBRIDGE (0223) 334540

FROM HEAD OF DEPARTMENT

PROFESSOR M. L. G. REDHEAD

13.5.90

Dear Paul,

I was very pleased to hear your exciting news about the appointment at Davis. Richard Healey will be an excellent colleague, and there is so much going on, on the West Coast generally. I very much enjoyed my visit to San Diego, and hope to complete arrangements for an exchange arrangement with Cambridge.

After Southern California, Moscow was a very different sort of experience, but everything is changing so rapidly over there, and there seems to be an enormous interest in philosophy of science and to learn more about Western ideas and approaches.

As I said on the telephone I have now had time to work through your

MLG

DIRECT LINE: CAMBRIDGE (0223) 334556

manuscript for the book. I think you have made a very good job of the whole thing, but here are a few specific comments, together with a list of typos on a separate sheet.

p. 34 para 3, line 7 ff.

You say here that the oscillators do not correspond to any physical system therefore oscillating in space-time. I think this needs more comment. the former emphasizes q(k) provide a set of collective coordinates for describing the configuration of the field. In this sense they are just as "real" as the 'displacement' amplitudes q(x). Fourier amplitudes are just a special case of generalized coordinates for specifying the configuration of the field. You seem to suggest they are somehow just mathematical fictions. But it is not unlike introducing the relative position and the location of the centre-of-mass for a 2-body system. Does the fact that there is nothing at the centre-of-mass

UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF HISTORY AND PHILOSOPHY OF SCIENCE

FREE SCHOOL LANE
CAMBRIDGE CB2 3RH
TEL: CAMBRIDGE (0223) 334540

FROM HEAD OF DEPARTMENT

PROFESSOR M. L. G. REDHEAD

11

make it an 'unphysical' conclusion?

p.38 I think a little more could be said here about the significance of anti commutans and the related idea of the spin-statistics theorem. As stressed by Green (IR 90 (1953), 270) anticommut. arise naturally as a possible quantization scheme, if one imposes the requirement that the Hamiltonian be the uniformly operator of time-displacement and remarks that the Hamiltonian itself is a bilinear form in the creation and destruction operators. The spin-statistics theorem shows that if attention is restricted to commutation or anticommutation at space-like separation, which is sufficient to guarantee that bilinear forms like the Hamiltonian, at commute at space-like separation, then no causal field is constructible with the wrong connection between spin and statistics.

p.T.O.

DIRECT LINE: CAMBRIDGE (0223) 334556

by a 'causal' field one means one
one which connects at
space-like separation with its canonically conjugate field
The clearest statement of this point is
in Weinberg (PR 133B (1964), 1318).

p42 Again you make this point that
the Fourier analysis of the electromagnetic
field is purely formal — but see my
comments above. In fn 2 you refer to
a different part of mine, that quantized
definite momenta are associated with
travelling waves, rather than standing
waves. For this point see also
Fermi (RMP 4 (1932), 87).

In para 2 you bring in the space-like
theorem again but without any attempt
to explain what is going on (see above).

p. 89 You say here that field quantization
appears that the classical field is
real valued. But a complex field can
always be regarded as a pair of
real fields.

p. 90 line 2 — perhaps you could add
here "known to do with gauge invariance and

UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF HISTORY AND PHILOSOPHY OF SCIENCE

FREE SCHOOL LANE
CAMBRIDGE CB2 3RH
TEL: CAMBRIDGE (0223) 334540

FROM HEAD OF DEPARTMENT

PROFESSOR M. L. G. REDHEAD

III

the associated peculiarities of photon spin"

p. 97 - 98

Jordan first to show on reality of oscillators in field quantization.

p. 98 to show re quantizing a complex field

p 108 End of para 2 to show re quantizing a complex field

p. 126 Hooy's theorem only denies the existence of the interaction representation. It is still possible to work in the Heisenberg representation. The result is essentially mathematical, concerned with the non-existence of certain unitary operators. It is no more serious than the physicists use of the S-function!

J. D.

DIRECT LINE: CAMBRIDGE (0223) 334556

p. 148 Para 2, line 2.
perhaps 'quanta' should read 'particles'?

p. 152 1st 2 lines
See above for comments on Fourier analysis. It all depends what you mean by "parts"!

I am convinced you should go ahead and publish under your own name. The work of drafting has been entirely your own, and you are characteristically generous in your reference to myself and Gordon in the introduction. The important thing is that this material should be available to philosophers, not specifically who writes it!

With very best wishes

Richard